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LAKE GENEVA, WALWORTH COUNTY, WISCONSIN.
EPA REGION V

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Wisconsin Department of Natural Resources
Wisconsin National Guard

July 1975

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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15. SUPPLEMENTARY NOTES
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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

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REPORT

ON

LAKE GENEVA

WALWORTH COUNTY

WISCONSIN

EPA REGION V

WORKING PAPER No. 61

WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

JULY, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nation-wide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS*

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

* The lake discussed in this report was included in the National Eutrophication Survey as a water body of interest to the Wisconsin Department of Natural Resources. Only the outlet stream was sampled, and this report relates only to the data obtained from lake sampling.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wisconsin Department of Natural Resources for professional involvement and to the Wisconsin National Guard for conducting the tributary sampling phase of the Survey.

Francis H. Schraufnagel, Acting Assistant Director, and Joseph R. Ball of the Bureau of Water Quality, and Donald R. Winter, Lake Rehabilitation Program, provided invaluable lake documentation and counsel during the Survey. Central Office and District Office personnel of the Department of Natural Resources reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

Major General James J. Lison, Jr., the Adjutant General of Wisconsin, and Project Officer CW-4 Donald D. Erickson, who directed the volunteer efforts of the Wisconsin National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

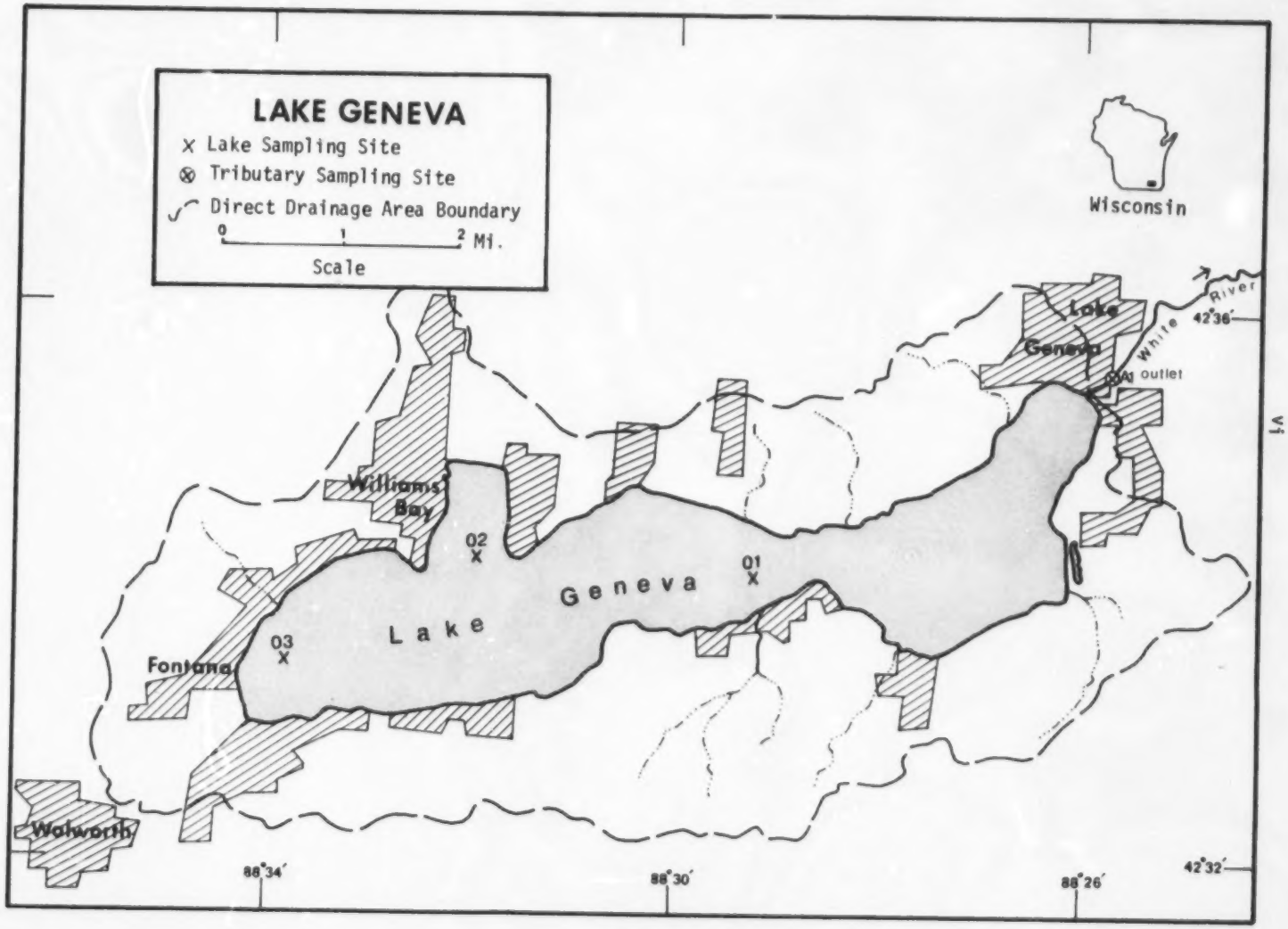
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WISCONSIN

LAKE NAME	COUNTY
Altoona	Eau Claire
Beaver Dam	Barron
Beaver Dam	Dodge
Big Eau Pleine	Marathon
Browns	Racine
Butte des Morts	Winnebago
Butternut	Price, Ashland
Castle Rock Flowage	Juneau
Como	Walworth
Crystal	Vilas
Delavan	Walworth
Eau Claire	Eau Claire
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
Middle	Walworth
Nagawicka	Waukesha
Oconomowoc	Waukesha
Okauchee	Waukesha
Petenwell Flowage	Juneau
Pewaukee	Waukesha
Pigeon	Waupaca
Pine	Waukesha
Poygan	Winnebago, Waushara
Rock	Jefferson
Rome Pond	Jefferson, Waukesha
Round	Waupaca
Shawano	Shawano
Sinnissippi	Dodge

LAKE NAME	COUNTY
Swan	Columbia
Tainter	Dunn
Tichigan	Racine
Townline	Oneida
Trout	Vilas
Wapogassett	Polk
Wausau	Marathon
Willow	Oneida
Winnebago	Winnebago, Fond Du Lac, Calumet
Wisconsin	Columbia
Wissota	Chippewa
Yellow	Burnett


LAKE GENEVA
Lake Sampling Site
Tributary Sampling Site
Direct Drainage Area Boundary
0
1
2 Mi.
Scale
Wisconsin
Lake
Geneva
White River
42°36'
Williams Bay
02
01
03
Fontana
Walworth
88°34'
88°30'
88°26'
42°32'

LAKE GENEVA

STORET NO. 5561

I. INTRODUCTION

Lake Geneva was included in the National Eutrophication Survey as a water body of interest to the Wisconsin Department of Natural Resources. No wastewater treatment plants impact the lake, and only the outlet stream was sampled (Appendix C). Therefore, this report only relates to lake sampling data.

The villages of Fontana on Lake Geneva and Williams Bay at the west end of the lake are served by secondary wastewater treatment plants and absorption lagoons with no discharge to surface waters; the effluent from the secondary facilities serving the City of Lake Geneva at the east end of the lake is discharged to the White River below the outlet of the lake (McKersie, et al., 1972).

II. CONCLUSIONS

A. Trophic Condition:

Survey data and reports of others (Lueschow, et al., 1970; Poff, et al., 1969) indicate Lake Geneva is mesotrophic. Of the 46 Wisconsin lakes sampled, four had less and one the same mean total phosphorus, four had less and one the same mean dissolved phosphorus, three had less mean inorganic nitrogen, 11 had less mean chlorophyll a, and five had greater mean Secchi

disc transparency. There was little depression of dissolved oxygen with depth at any of the three sampling stations in August (to depths of 100 feet); but near-depletion occurred at station 2 in November, 1972 (at 96 feet).

Although chemicals have been used for a number of years (Lueschow, 1972), Poff, et al. (1969) noted that rooted aquatic vegetation and filamentous algae generally were sparse and observed that "Even under these seemingly ideal conditions, there have been annual applications of...chemicals for the control of aquatic nuisances...".

B. Rate-Limiting Nutrient:

There was a 50% loss of dissolved phosphorus and a 16% gain in inorganic nitrogen in the algal assay sample between the time of collection (11/10/72) and the beginning of the assay. This change shifted the limiting nutrient from nitrogen in the lake (N/P = 8/1) to phosphorus limitation in the sample (N/P = 15/1), and the assay results are not representative of lake conditions at the time the sample was taken.

The lake data indicate nitrogen limitation in June as well (N/P = 7/1) but phosphorus limitation in August (N/P = 18/1).

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 5,262 acres.
2. Mean depth: 61 feet.
3. Maximum depth: 135 feet.
4. Volume: 320,984 acre-feet.
5. Mean hydraulic retention time: 29 years (24 years with outflow given below).

B. Outlet:
(See Appendix A for flow data)

Name	Drainage area (mi^2)*	Mean flow (cfs)
White River	28.6**	18.5

C. Precipitation***:

1. Year of sampling: 38.7 inches.
2. Mean annual: 32.9 inches.

† Poff, et al., 1969.
* Drainage areas are accurate within ±0.5%; mean daily flows are accurate within ±40%; mean monthly flows are accurate within ±35%; and normalized monthly flows are accurate within ±35%.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods, 1972".

IV. LAKE WATER QUALITY SUMMARY

Lake Geneva was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 50 feet at station 1, 100 feet at station 2, and 95 feet at station 3.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/10/72)		
Temperature (Cent.)	7.3	9.0	9.2	9.3
Dissolved oxygen (mg/l)	0.6	8.5	9.0	9.6
Conductivity (μmhos)	390	399	400	400
pH (units)	7.5	8.1	8.1	8.2
Alkalinity (mg/l)	177	184	183	190
Total P (mg/l)	0.015	0.019	0.017	0.047
Dissolved P (mg/l)	0.007	0.010	0.009	0.039
NO_2 + NO_3 (mg/l)	0.010	0.041	0.040	0.180
Ammonia (mg/l)	0.030	0.038	0.040	0.090
		ALL VALUES		
Secchi disc (inches)	105	126	123	144

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/21/72	1. Dinobryon	497
	2. Oocystis	416
	3. Flagellates	226
	4. Flagilaria	217
	5. Synedra	99
	Other genera	425
	Total	1,880
08/16/72	1. Microcystis	1,463
	2. Merismopedia	875
	3. Chroococcus	634
	4. Dinobryon	332
	5. Synura	196
	Other genera	542
	Total	4,042
11/10/72	1. Dinobryon	1,036
	2. Flagellates	942
	3. Oscillatoria	301
	4. Navicula	245
	5. Asterionella	245
	Other genera	1,035
	Total	3,804

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/21/72	01	7.8
	02	2.8
	03	4.4
08/16/72	01	2.0
	02	2.2
	03	2.2
11/10/72	01	13.4
	02	9.4
	03	7.7

V. LITERATURE REVIEWED

Lueschow, Lloyd A., 1972. Biology and control of aquatic nuisances in recreational waters. Tech. Bull. No. 57, WI Dept. Nat. Resources, Madison.

_____, James M. Helm, Donald R. Winter, and Gary W. Karl; 1970. Trophic nature of selected Wisconsin lakes. Trans. Wisc. Acad. Sci., Arts & Ltrs., vol. 58, pp. 237-264.

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Poff, Ronald J., and C. W. Threinen, 1961. Surface water resources of Walworth County. WI Cons. Dept., Madison.

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VI. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5561 LAKE GENEVA

TOTAL DRAINAGE AREA OF LAKE 28.60

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5561A1	28.60	12.00	13.00	30.00	30.00	23.00	33.00	14.00	11.00	14.00	14.00	15.00	13.00	18.50
5561ZZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 28.60
SUM OF SUB-DRAINAGE AREAS = 0.0
TOTAL FLOW IN = 0.0
TOTAL FLOW OUT = 222.00

NOTE *** NO INLET STREAMS

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5561A1	9	72	53.00	23	75.00				
	10	72	36.00	20	21.00				
	11	72	28.00	29	18.00				
	12	72	18.00	27	15.00				
	1	73	28.00	29	23.00				
	2	73	21.00	24	13.00				
	3	73	56.00	20	52.00				
	4	73	150.00	14	130.00	30	150.00		
	5	73	62.00	17	48.00	26	48.00		
	6	73	28.00	22	26.00				
	7	73	9.00	22	17.00				
	8	73	5.50	24	8.00				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

556101
42 33 54.0 088 29 18.0
LAKE GENEVA
55 WISCONSIN

11EPALES 2111202
3 0020 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/21	17	20 0000	19.5	9.2	120	340	8.50	178	0.020	0.020	0.013	0.006
	17	20 0015	19.4	9.2		345	8.50	177	0.020	0.030	0.016	0.010
72/08/16	16	30 0000			140	370	8.45	164	0.050	0.060	0.010	0.006
	16	30 0004	22.5	9.3		365	8.45	165	0.050	0.060	0.010	0.006
	16	30 0015	21.9	9.4		370	8.40	162	0.060	0.060	0.011	0.006
	16	30 0040	17.9	8.2		395	8.20	171	0.050	0.050	0.011	0.005
72/11/10	08	00 0000			105	400	8.20	183	0.020	0.040	0.017	0.009
	08	00 0004	8.9	9.4		400	8.20	183	0.020	0.030	0.017	0.008
	08	00 0015	8.9	9.2		400	8.20	185	0.020	0.030	0.017	0.009
	08	00 0025	8.9	9.6		400	8.20	183	0.010	0.030	0.017	0.008
	08	00 0040	8.9	9.5		400	8.20	183	0.020	0.040	0.018	0.009
	08	00 0050	8.9	9.1		400	8.10	187	0.020	0.040	0.022	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	17	20 0000	7.8J
72/08/16	16	30 0000	2.0J
72/11/10	08	00 0000	13.4J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

556102
42 33 48.0 088 32 06.0
LAKE GENEVA
55 WISCONSIN

11EPALES
3

2111202
0070 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/21	17	35 0000	19.1	10.1	144	340	8.60	178	0.020	0.020	0.013	0.005
	17	35 0015	19.0	10.0		340	8.60	180	0.010	0.020	0.014	0.005
	17	35 0030	11.1	11.0		345	8.40	181	0.010	0.020	0.019	0.008
	17	35 0060	6.6	10.4		350	8.20	182	0.020	0.040	0.010	0.005
72/08/16	15	40 0000			124	382	8.40	165	0.050	0.050	0.010	0.005
	15	40 0004	22.3	9.2		380	8.40	165	0.060	0.050	0.009	0.005
	15	40 0015	22.1	9.1		375	8.30	165	0.060	0.050	0.009	0.005
	15	40 0040	13.2	8.2		395	8.00	179	0.050	0.050	0.014	0.006
	15	40 0045	9.8									
	15	40 0050	8.5	7.1		400	7.80	182	0.080	0.050	0.010	0.006
	15	40 0055	8.4									
	15	40 0060	7.8									
	15	40 0065	7.6									
	15	40 0070	7.4									
	15	40 0075	7.3	6.9		405	7.80	182	0.110	0.050	0.010	0.006
	15	40 0100	6.1	6.4		403	7.75	183	0.190	0.050	0.023	0.013
72/11/10	08	50 0000			122	400	8.10	187	0.040	0.030	0.016	0.007
	08	50 0004	9.2	9.8		400	8.10	188	0.040	0.030	0.015	0.008
	08	50 0015	9.2	8.5		400	8.10	186	0.040	0.040	0.016	0.008
	08	50 0035	9.2	9.5		400	8.10	181	0.040	0.030	0.015	0.007
	08	50 0055	9.2	8.6		400	8.10	182	0.040	0.040	0.016	0.007
	08	50 0075	9.3	8.7		400	8.20	184	0.040	0.040	0.015	0.007
	08	50 0096	7.3	0.6		400	7.50	190	0.180	0.090	0.047	0.039

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	17	35 0000	2.8J
72/09/16	15	40 0000	2.2J
72/11/10	08	50 0000	9.4J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

14

556103
42 33 12.0 088 33 48.0
LAKE GENEVA
55 WISCONSIN

11EPALES
3

2111202
0065 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/21	18	05 0000	19.4			345	8.60	178	0.010	0.030	0.012	0.007
	18	05 0015	19.4	9.5								
	18	05 0030	11.2	10.8		350	8.40	181	0.010	0.030	0.020	0.006
	18	05 0060	6.4	9.0		350	8.00	180	0.020	0.040	0.015	0.005
72/08/16	17	00 0000			134	385	8.45	166	0.060	0.060	0.009	0.005
	17	00 0004	22.3	9.3		383	8.45	166	0.050	0.060	0.010	0.005
	17	00 0015	22.1	9.2		380	8.43	167	0.050	0.060	0.013	0.006
	17	00 0025	19.3	8.8		383	8.30	167	0.050	0.060	0.012	0.006
	17	00 0035	13.1	8.4		400	7.90	175	0.040	0.050	0.016	0.006
	17	00 0045	9.6	7.6		400	7.85	177	0.050	0.050	0.011	0.006
	17	00 0055	8.3	7.7		405	7.83	185	0.050	0.050	0.011	0.006
	17	00 0065	7.4	7.5		407	7.80	176	0.080	0.060	0.011	0.006
	17	00 0075	7.0	7.8		410	7.80	178	0.100	0.060	0.010	0.006
	17	00 0085	6.8	7.4		415	7.80	183	0.120	0.060	0.010	0.006
	17	00 0095	6.4	6.9		380	7.85	181	0.140	0.060	0.022	0.009
72/11/10	09	35 0000			120	390	7.90	177	0.040	0.040	0.015	0.008
	09	35 0004	9.2	8.7		400	8.00	182	0.040	0.040	0.017	0.009
	09	35 0015	9.2	8.7		400	8.00	182	0.040	0.040	0.017	0.009
	09	35 0025	9.2									
	09	35 0035	9.2	9.0		400	8.00	185	0.040	0.040	0.019	0.010
	09	35 0045	9.2									
	09	35 0055	9.2	9.0		400	8.00	182	0.040	0.030	0.019	0.009
	09	35 0065	9.2									
	09	35 0075	9.2	9.2		400	8.00	184	0.040	0.030	0.019	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	18	05 0000	4.4J
72/08/16	17	00 0000	2.2J
72/11/10	09	35 0000	7.7J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/02

5561A1 LS5561A1
42 36 00.0 088 26 00.0
WHITE RIVER
55 15 LAKE GENEVA
0/LAKE GENEVA
ST HWY 50 BRDG SE CORNER LAKE GENEVA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/23	08 45		0.037	1.760	0.099	0.005K	0.016
72/10/20	16 40		0.069	1.200	0.129	0.039	
72/11/29	15 30		0.031	0.565	0.009	0.005K	0.028
72/12/27	09 25		0.066	0.580	0.315	0.005K	0.023
73/01/29	15 30		0.058	0.390	0.012	0.005K	0.020
73/02/24	12 15		0.034	0.540	0.012	0.010	0.015
73/03/20	12 00		0.168	1.300	0.123	0.008	
73/04/14	16 20		0.011	0.500	0.012	0.005K	0.025
73/04/30	15 20		0.044	1.680	0.074	0.006	0.060
73/05/17	17 15		0.015	0.690	0.010	0.012	0.030
73/05/26	12 35		0.010K	1.800	0.046	0.006	0.025
73/06/22	14 30		0.013	0.460	0.011	0.008	0.015
73/07/22	12 30		0.019	0.420	0.031	0.005K	0.020
73/08/24	09 40		0.044	1.200	0.080	0.020	0.025

K VALUE KNOWN TO BE LESS THAN INDICATED